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The Effects of Isometric Contraction Exercise on Reaction and Speed of Movement Times.

Charles Edward Michael
Louisiana State University and Agricultural & Mechanical College

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THE EFFECTS OF ISOMETRIC CONTRACTION EXERCISE ON REACTION AND SPEED OF MOVEMENT TIMES

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Charles E. Michael
dward
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ABSTRACT

During recent years the use of isometric contraction exercises has spread widely in programs of physical activity. Scientific evidence indicated that this form of training was conducive to gains in strength. Very little data, however, have been reported on its influence on other factors which are considered important in physical performance. The purpose of this investigation was to determine the effects of functional isometric exercises on arm reaction time, arm movement time, leg reaction time, and leg movement time. The movements tested were a sixteen inch lateral abductive movement of the arm and a fourteen inch forward extension of the leg performed from a sitting position.

Four groups of thirty-four college males served as subjects for this investigation. Group I served as a control group and was assigned no physical activity. Group II participated in a functional isometric exercise program which consisted of one arm exercise and one leg exercise performed three days a week. Group III took part in a six-week unit of basic softball fundamentals as part of the regular program of physical education. Group IV was assigned both softball activity and the isometric exercises. All subjects were tested at the beginning and at the end of a six-week training period.

Testing equipment designed and made for this study included the Hewlett-Packard Electronic Counter which was started and stopped by a series of photo-electric cells with flashlights as a light source.

Each subject was given three test trials in each of the four measurements of reaction and movement times studied. Each measurement was recorded in ten-thousandths of a second. The subject's score for each event was the sum of the three trial measurements. The subjects who participated in the isometric exercise program were also tested for arm and leg strength for motivational purposes.

A two by two factor analysis of co-variance was used to analyze the data gathered. This analysis revealed significant gains in arm reaction time, arm movement time, leg reaction time, and leg movement time in favor of the isometric exercise groups as opposed to the non-isometric groups. The addition of softball to the exercise program caused a slower final mean score in arm reaction time. These differences were significant at the .01 level of confidence. The interaction of softball and isometric exercise in the other three variables did not cause significant changes. No significant difference was found in any of the four variables for the softball groups versus the non-softball groups. Significant gains at the .01 level were found in both the arm and leg strength scores.

As a result of this analysis, the following conclusions were justified:

1. Functional isometric contraction exercises were responsible for highly significant improvements in reaction times and speed of movement times of the arm and leg.
2. The addition of softball activity to the functional isometric exercise program did not cause significant gains in reaction time and movement time as opposed to the use of isometric exercise alone.
3. Softball activity alone did not result in any significant change in reaction and movement time as measured in this study.

CHAPTER I

INTRODUCTION

Physical educators and athletic coaches have conducted a considerable amount of research on reaction time and movement time. Although much information has resulted, there is very little conclusive data pertaining to the effects of physical activity on these two factors.

Neuromotor specificity dominance led Henry[1] to surmise that there was little or no correlation between static dynamometer strength and speed of movement, but that speed of movement could possibly be increased by strengthening the muscles which caused the movement. Research by Endres[2] showed a division of prior opinion on the relationship between strength increases and improvements in movement speeds. Strength increases in excess of a certain minimum amount were found by him to contribute little or nothing to speed of movement.

Practice and training were formerly considered to be the only

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[1] Franklin M. Henry, "Factorial Structure of Speed and Static Strength in a Lateral Arm Movement," Research Quarterly, 31:3 (1959), pp. 440-47.

[2] John Paul Endres, "The Effect of Weight Training Exercise upon the Speed of Muscular Movement," Microcarded Master's Thesis, University of Wisconsin, Madison, 1953. p. 1.

methods available for improving reaction time.[3] In a review of the literature concerning reaction time, Glines[4] found that studies in both psychology and physical education were inconclusive and often contradictory. He expressed uncertainty as to the effects of sports participation and physical activity on reaction time.

During recent years isometric exercises as a means of training have gained increased and widespread use in physical education and athletics. With the increased use of this type of training, numerous research studies attempted to determine its optimum use in programs of physical activity. Most of these studies found this type of training to be helpful in improving strength (see Chapter II). Contemporary literature, however, contains very little information regarding the influence of this type of training on other factors, such as reaction time and movement time.

I. PURPOSE OF THE STUDY

It was the purpose of this study to determine the effects of functional isometric contraction exercises on the following:

1. Reaction time of a selected movement of the arm.

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[3] Sidney Calvin, "An Analysis of the Effects of Progressive Heavy Resistance Exercise on the Motor Co-Ordination of a Group of High School Boys, Ages Fourteen to Eighteen," Microcarded Doctor's Dissertation, University of Maryland, College Park, 1958. p. 18.

[4] Don Glines, "Relationships of Reaction, Movement, and Completion Times to Certain Motor, Strength, Anthropometric and Maturity Measures," Microcarded Doctor's Dissertation, University of Oregon, Eugene, 1960. p. 3.

2. Movement time of a selected movement of the arm.
3. Reaction time of a selected movement of the leg.
4. Movement time of a selected movement of the leg.

II. SIGNIFICANCE OF THE STUDY

Physical educators, coaches, and others engaged in programs of physical activity need scientific information on methods for improving all phases of physical performance. Past literature produced conflicting opinions as to whether physical training improves reaction time and movement time. Evidence supporting or denying the hypothesis that isometric exercises would improve reaction time and movement time would add significant knowledge about the value of this type of training on physical performance.

III. LIMITATIONS OF THE STUDY

This study was limited to a training period of six weeks of isometric contraction exercises. The subjects were limited to one ten second contraction performed three days a week.

Except for an attempt to maintain normal room temperature during testing periods, it was considered that the temperature of the muscles could not be controlled in this study; this possibly could have had some influence on the speed of muscular responses recorded in this study.

A further limitation was that only one arm movement and one leg movement were used to test the reaction and movement times of these limbs.

IV. BASIC ASSUMPTIONS

The subjects were assumed to be equally motivated to perform at their best during all testing and exercise sessions conducted in this study.

It was assumed that the tests used in this study were valid measures of reaction and movement times.

While outside activities were recognized as being capable of affecting these factors, the outside activities of the participating subjects were presumed to be limited and controlled.

V. DEFINITION OF TERMS USED

Reaction Time. The elapsed time between the presentation of a light stimulus and the initiation of the movement under study.[5]

Movement Time. The interval between the initiation of the contraction and the completion of the movement.[6]

Arm Movement. A sixteen inch lateral abductive movement of the arm.

Leg Movement. A fourteen inch forward extension of the leg performed from a sitting position.

Isometric Contraction. Development of tension without a

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[5] M. Gladys Scott, Chairman. *Research Methods Applied to Health, Physical Education, and Recreation*, American Association for Health, Physical Education, and Recreation, (Washington, 1949), p. 287.

[6] *Ibid*.

shortening of the muscle fiber.[7]

Functional Isometric Contraction. An isometric contraction with the muscle positioned as it would be in an activity.

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[7]Laurence E. Morehouse and Augustus T. Miller, Jr., Physiology of Exercise (St. Louis: The C. V. Mosby Co., 1959), p. 27.

CHAPTER II

REVIEW OF RELATED LITERATURE

The review of related literature which is presented in this chapter is given under three main headings: (1) Studies Related to Isometric Strength Gains, (2) Studies Related to the Effects of Physical Activity on Reaction Time, and (3) Studies Related to the Effect of Physical Activity on Movement Time.

I. STUDIES RELATED TO ISOMETRIC STRENGTH GAINS

During recent years more and more people interested in physical development have instituted programs of isometric contraction exercises to promote strength among their pupils. Research studies indicated that this type of training was useful for this purpose.

Rarick and Larsen[1] divided thirty boys into one control and two experimental groups which were given four weeks of isometric flexion of the right wrist. The result indicated that one six second isometric exercise performed daily at two-thirds effort was as beneficial for strength development as were more frequently repeated exercises done at higher levels of tension.

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[1]Lawrence Rarick and Gene L. Larsen, "Observation on Frequency and Intensity of Isometric Muscular Effort in Developing Muscular Strength," Research Quarterly, 29:3 (October, 1958), pp. 333-41.

One hundred and twenty college males from Springfield College exercised two, three, four, and five times a week in an effort to investigate the effects of both isometric and isotonic exercises on strength development. The results of this investigation led Mathews and Kruse[2] to surmise that isometric exercises caused a greater number of the subjects to gain significantly in strength than did the isotonic exercises. They further concluded that the five day a week program was the most beneficial in terms of strength gains.

Four tests of strength were administered by Wolbers and Sills[3] to two groups of high school students at the beginning and end of an eight week training period. The experimental group performed isometric exercises and made greater gains in the tests of the back lift, leg lift, and combined hand grip test than did the control group. From the results of the data gathered in this project, the authors concluded that static muscular contraction for a six second period would cause significant gains in strength.

Barham[4] compared the effectiveness of different frequencies

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[2]Donald K. Mathews and Robert Kruse, "Effects of Isometric and Isotonic Exercises on Elbow Flexor Muscle Groups," Research Quarterly, 28:1, (March, 1957), pp. 26-37.

[3]Charles P. Wolbers and Frank D. Sills, "Development of Strength in High School Boys by Static Muscle Contractions," Research Quarterly, 27:4, (December, 1956), pp. 446-55.

[4]Jerry N. Barham, "A Comparison of the Effectiveness of Isometric and Isotonic Exercises when Performed at Different Frequencies per Week," Doctor's Dissertation, Louisiana State University, Baton Rouge, 1960. p. 56.

of isometric and isotonic exercises and found the following:

1. A significant improvement in muscular strength can be obtained through a program of isometric exercises.

2. The addition of isotonic exercise to a maximum isometric contraction does not affect the gain in strength above the use of isometric exercise alone.

3. There was no significant difference in terms of gains in strength between exercises performed five and three days a week.

4. Strength gains in five and three days a week programs were significantly greater than those obtained by two day a week programs.

Two groups of ten subjects were utilized by Dennison and others[5] to determine the relative strength gains resulting from isometric and isotonic training programs. Both groups exhibited significant improvements in chinning and dipping ability which improved arm strength. No significant difference was found between the improvements in mean scores of the two groups.

Adamson[6] conducted an eight-week investigation to study the relative effects of both isometric and isotonic exercise programs on strength development. Significant gains in strength were reported in both programs, however there was no significant difference between the two methods of training for the development of muscular strength.

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[5] D. D. Dennison, et al., "Effect of Isometric and Isotonic Exercise Programs upon Muscular Endurance," Research Quarterly, 32:3, (October, 1961), pp. 348-52.

[6] G. T. Adamson, "Effects of Isometric and Isotonic Exercises on Elbow Flexor and Spine Extensor Muscle Groups," Health and Fitness in the Modern World, 1961. p. 172.

II. STUDIES RELATED TO MOVEMENT TIME

In order to determine the effects of weight training upon speed of muscular contraction, Zorbas and Karpovich[7] used an experimental group of men who had participated in weight training programs and a control group of men who had never engaged in weight training. Evidence gathered indicated that the experimental group was faster in rotary motions of the arm than was the control group.

The hypothesis that training with heavy exercises of the resistance type caused slower speed of movement was tested by Wilkin.[8] He concluded that weight training over a period of one semester had no slowing influence on speed of arm movement. He further concluded that a semester of weight training did not increase speed of movement more than a semester of beginning swimming or golf and that the weight lifter's speed of movement is not impaired. His speed was as great as that of other students studied and improved as much or more during a semester of training.

Two groups of freshmen enrolled at Pennsylvania State University were investigated by Swegan[9] to determine the effect of static

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[7]William S. Zorbas and Peter V. Karpovich, "The Effect of Weight Lifting upon the Speed of Muscular Contraction," Research Quarterly, (May, 1951), pp. 145-48.

[8]Bruce M. Wilkin, "The Effect of Weight Training on Speed of Movement," Research Quarterly, 23:3, (October, 1952), pp. 361-69.

[9]Donald B. Swegan, "The Comparison of Static Contraction with Standard Weight Training in Effect on Certain Movement Speeds and Endurance," Microcarded Ed.D. Dissertation, 1957, Pennsylvania State University, College Park, p. 139.

contraction and standard weight training procedures on certain movement speeds and endurance. One group trained with standard weight methods, while the other used static contraction methods consisting of contractile pulls for six seconds at two-thirds maximum pull. It was found that the static contraction group was slowed down in each of the eight movements tested, while the weight group was slowed down in six of the eight movements under study.

The influences of weight training on speed of movement were studied by Endres.[10] He discovered that weight training exercises had no detrimental effect upon the speed of elbow flexion and extension. He indicated that increases in speed of movement due to weight training were accompanied by marked increases in strength.

Freshman and varsity football players were studied by Meadows[11] to investigate the effects of isotonic and isometric muscle contractions on speed of the offensive football charge, static strength and dynamic strength. Three groups were employed: (1) an isotonic group which engaged in a weight training program, (2) an isometric group which participated in a static pull training program, and (3) a control group which engaged in the regular physical education program. Both isotonic and isometric programs improved significantly the speed of the offensive football charge. The results supported the hypothesis

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[10] Endres, op. cit., p. 30.

[11] Paul Eugene Meadows, "The Effect of Isotonic and Isometric Muscle Contraction Training on Speed, Force, and Strength," Microcarded Ph.D. Dissertation, 1959, University of Illinois, Urbana, p. 95.

that the development of strength in the isotonic and isometric program had beneficial effects on the speed and force of the offensive football charge.

Clarke and Henry[12] measured sixty-two college men for arm strength, effective arm mass, and speed in a lateral adductive arm movement. Half of this group were given weight training exercises that did not involve the movement, while the other half remained inactive to provide a control group. The length of the training period for both groups was ten weeks. They concluded that conditioning exercises of the progressive resistance type, that do not directly involve a lateral arm movement, caused increased strength and speed of movement. It was further concluded that the conditioning exercises used in this experiment had no influence on reaction time ability.

Masley and others[13] found that a six-week period of weight training increased speed and coordination more than a similar period of volleyball or inactivity. They concluded that increased strength gained through training with weight was apparently associated with increased muscular coordination and speed of movement.

Boys ranging in age from fourteen to eighteen engaged in a

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[12] David H. Clarke, and Franklin M. Henry, "Neuro-motor Specificity and Increased Speed from Strength Development," Research Quarterly, 32:3, (October, 1961), pp. 315-25.

[13] John W. Masley and others, "Weight Training in Relation to Strength, Speed, and Coordination," Research Quarterly, 24:3, (October, 1953), pp. 308-15.

program of progressive resistance exercises for a period of four months in order to investigate the influence of a weight program on motor co-ordination, speed of movement, passing accuracy, and dexterity. As a result of this study, Calvin[14] concluded that a four month program of weight training significantly increased the speed of movement of the subjects studied.

III. STUDIES RELATED TO REACTION TIME

Forty-six subjects were assigned by Burpee and Stroll[15] to groups according to athletic ability and athletic participation in an investigation of the relationship among small muscle reaction time, large muscle reaction time, and successful participation in the YMCA athletic programs. The authors reported a significant relationship between small muscle reaction time and successful participation in the athletic program.

Seventy-five college women engaged in selected physical education activities were measured by Beise and Perseley[16] for reaction time in

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[14] Sidney Calvin, "An Analysis of the Effects of Progressive Heavy Resistance Exercise on the Motor Co-ordination of a Group of High School Boys, Ages Fourteen to Eighteen," Microcarded Doctor's Dissertation, 1958. University of Maryland: College Park. p. 96.

[15] Royal H. Burpee and Wellington Stroll, "Measuring Reaction Time of Athletics," Research Quarterly, 7:1 (March, 1936), pp. 110-18.

[16] Dorothy Beise and Virginia Perseley, "Relation of Reaction Time, Speed and Agility of Big Muscle Groups to Certain Sports Skills," Research Quarterly, 8:1 (March, 1937), pp. 133-42.

removing the foot from a plate, pushing down on a plate with the hand, and removing the hand from the plate. This investigation revealed that training in beginning golf, tennis, and archery for a period of fourteen weeks did not cause significant changes in reaction times.

Woodward[17] compared the results of a progressive weight program and a required physical education program on strength, endurance, reaction time, and balance. His general findings were that weight training when added to a physical education program significantly aided in the development of strength, endurance, reaction time, and balance of high school boys.

The effects of a weight training program on total body reaction time were studied over a fourteen week period by Anderson.[18] He found that the weight training group improved in all reaction time tests studied, although these improvements were not statistically significant.

The reaction times of 359 athletes and 255 non-athletes from high school and college were measured by Keller.[19] He found that football, basketball, track, and baseball players were faster in reaction time than were the non-athletes measured in the study.

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[17] James Woodward, "Progressive Weight Training in Physical Education," Completed Research in Health, Physical Education and Recreation, Research Council, American Association for Health, Physical Education and Recreation, Vol. 2, 1960, p. 57.

[18] Robert W. Anderson, "The Effect of Weight Training on Total Body Reaction Time," Unpublished Master's thesis, University of Illinois, Urbana, 1957. 66 pp.

[19] Louis F. Keller, "The Relation of 'Quickness of Bodily Movement' to Success in Athletics," Research Quarterly, 13:2, (May, 1942), pp. 146-56.

Kurt[20] undertook a study to determine the consequences of weight training on balance, response time, and hand-eye coordination. Twenty-three college men served as subjects and participated in a program of weight training twice a week for twelve weeks. The conclusions were that weight training was beneficial in improving the scores on all three items under consideration.

Youngen[21] compared the reaction time and movement time scores of forty-seven women athletes with similar scores of seventy-five women non-athletes. The athletes were divided into groups of tennis players, fencers, swimmers, and field hockey players. The women athletes were found to be significantly faster than the non-athletes in speed of movement and reaction time.

Data from 108 undergraduate college men participating in selected physical education activities and athletics for a period of several months were collected by Genasci[22] in an attempt to determine the effects of these activities on total body reaction and movement times. The analysis of variance technique indicated a significant

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[20] Charles P. Kurt, "The Effect of Weight Training on Hand Eye Co-ordination, Balance, and Response Time," Microcarded Master's Thesis, 1956. University of Iowa: Iowa City. p. 26.

[21] Lois Youngen, "A Comparison of Reaction and Movement Times of Women Athletes and Non-Athletes," Research Quarterly, 30:3, (October, 1959), pp. 349-55.

[22] James E. Genasci, "A Study of the Effects of Participation in Physical Education and Athletics on Reaction and Movement Time," Completed Research in Health, Physical Education and Recreation, Vol. 3, 1961, p. 26.

trend at the .01 level toward improved reaction and movement times from the first to the last testing period.

Three groups of college men, designated as athletes, intermediates, and non-athletes were measured by Olsen[23] for simple, choice, and discriminatory reaction times. The investigation found the athletes to have faster reaction times than the non-athletes, and intermediates to be faster than non-athletes in all three tests of reaction time.

IV. SUMMARY OF RELATED STUDIES

There was general agreement in the literature relative to the value of isometric training in terms of strength gain.[24] These studies supported the hypothesis that significant gains in strength resulted from training with isometric contraction exercises.

Conflicting opinion, however, was reported on the effects of weight training and isometric exercises on speed of movement time. Swegan[25] indicated that both isotonic and isometric training caused slower speeds of movement, while two studies found that weight training did not produce any detrimental effects on speed of movement.[26]

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[23] Einar A. Olsen, "Relationship Between Psychological Capacities and Success in College Athletics," Research Quarterly, 27:1, (March, 1956), pp. 79-89.

[24] Supra, Barham, Rarick and Larsen, Mathews and Kruse, Wolbers and Sills, and Dennison et al.

[25] Supra, Swegan.

[26] Supra, Wilkins, Zorbas and Karpovich.

Five studies on the influence of weight training on speed of movement found that type of training did cause improved speed of movement times.[27]

The results of a number of studies, reviewed in the literature, indicated that participation in athletics and selected physical activities[28] or weight training[29] resulted in improvements in reaction time. Only one study failed to find any change in speed of reaction time as a result of certain women's physical education activities.[30]

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[27]Supra, Calvin, Meadows, Clarke and Henry, Masley, Endres.

[28]Supra, Burpee and Stroll, Keller, Youngen, Genasci, and Olsen.

[29]Supra, Calvin, Woodward, Anderson, and Kurt.

[30]Supra, Beise and Perseley.

CHAPTER III

PROCEDURES OF THE STUDY

The parallel group technique was used for determining the effects of isometric contraction exercise on the reaction and movement times measured in this study. All subjects were administered tests of arm reaction time, arm movement time, leg reaction time, and leg movement time at the beginning of the experiment. The subjects in this study were placed in four groups as follows: one group performed isometric exercises only; one group was engaged in an activity, softball, in addition to performing isometric exercises; a third group engaged in softball only; and the fourth group served as a control group. At the end of the six-week training period, all subjects were retested in order to determine the effects of the isometric program on these variables.

I. SUBJECTS

One hundred thirty-six college men divided into four groups served as subjects for this study.[1] All subjects were students at Louisiana Polytechnic Institute at Ruston, Louisiana, and ranged in

[1]At the conclusion of the study, Group I had the least number of subjects--thirty-four. It was necessary to have equal numbers in all groups in order to facilitate the treatment of the data by the IBM Computer. Therefore, ten subjects were eliminated, at random, from the other three groups.

age from eighteen to twenty-four years. The subjects were students who had been previously assigned to regularly scheduled classes in the Department of Health, Physical Education, and Recreation and the Department of English. Because varsity athletes and those already participating in other forms of organized physical training programs were considered to be more highly trained than were the non-athletes, they were excluded from this project. The subjects were assigned to the following groups:

Group I. The subjects in Group I served as a control group and were not assigned any form of physical activity. These students were enrolled in non-activity classes and were requested not to engage in any physical training program during the time of the study.

Group II. The subjects assigned to this group were enrolled in lecture courses in English and Physical Education and participated in the isometric exercise program which consisted of one arm and one leg exercise. During the six-week course of this study, these subjects were requested not to engage in any other form of physical training other than the isometric exercises prescribed to them. The two exercises are described on page 25.

Group III. The activity in which the subjects in Group III were engaged consisted of a six week unit of basic fundamentals of softball and included hitting, fielding, throwing, batting, and running. All subjects were students enrolled in the regular activity courses of physical education. They were required to meet class fifty minutes a day, three times a week.

Group IV. In Group IV were students also enrolled in the required activity classes in physical education. This group performed the same isometric exercise program as did Group II, but in addition the subjects took part in the same six week unit of softball as Group III as part of the regular program of physical education.

II. TESTING EQUIPMENT

Special apparatus designed and constructed by Associate Professor Francis Roy of the Electrical Engineering faculty of Louisiana Polytechnic Institute at Ruston, Louisiana, was used to measure the reaction and movement times studied. Components of this equipment are described below.

Timer. A Hewlett-Packard Electronic Counter, Model 522, was utilized for recording scores on the tests of reaction and movement times.

Starter. A silent pushbutton starter was used to flash the signal light and simultaneously start the timer in the reaction phases of the arm and leg tests. The starter was not visible to the subjects during the administration of the tests.

Light Stimulus. As the stimulus for arm and leg reaction tests, a red signal light flashed by the pushbutton starter was employed. The stimulus was presented at different time intervals in order to prevent the testees from anticipating the signal. The intervals ranged from one to five seconds.

Rotary Selector. A four place selector was used to change the wiring mechanism for each of the four tests used. The four positions were: (1) arm reaction, (2) arm movement, (3) leg reaction, and (4) leg movement.

Arm Testing Apparatus. The arm testing apparatus consisted of two photo-electric cells wired to start and stop the electronic timing device. The cells were mounted on wooden standards and placed sixteen inches apart. Light sources for the cells were furnished by flashlights positioned below the cells. The flashlights were placed eighteen inches apart to allow for individual differences in the heights of the subjects.

A movable metal bar was placed behind the initial photo-electric cell to insure a standard starting position on the arm tests.

The testing apparatus and starting position for the arm tests are shown in Figure 1.

Leg Testing Apparatus. For the tests of leg reaction time and leg movement time, similar apparatus to that used in the arm tests was constructed. The photo-electric cells were placed fourteen inches apart and mounted on wooden standards. The first cell was mounted four inches above the floor and the final cell was mounted eight inches above the floor. Flashlights were used as light sources.

The subjects were seated on a wooden bench which could be adjusted to the desired distance behind the initial photo-electric cell, to insure the same starting position for all subjects.

The apparatus used for the leg tests is shown in Figure 2, page 22.

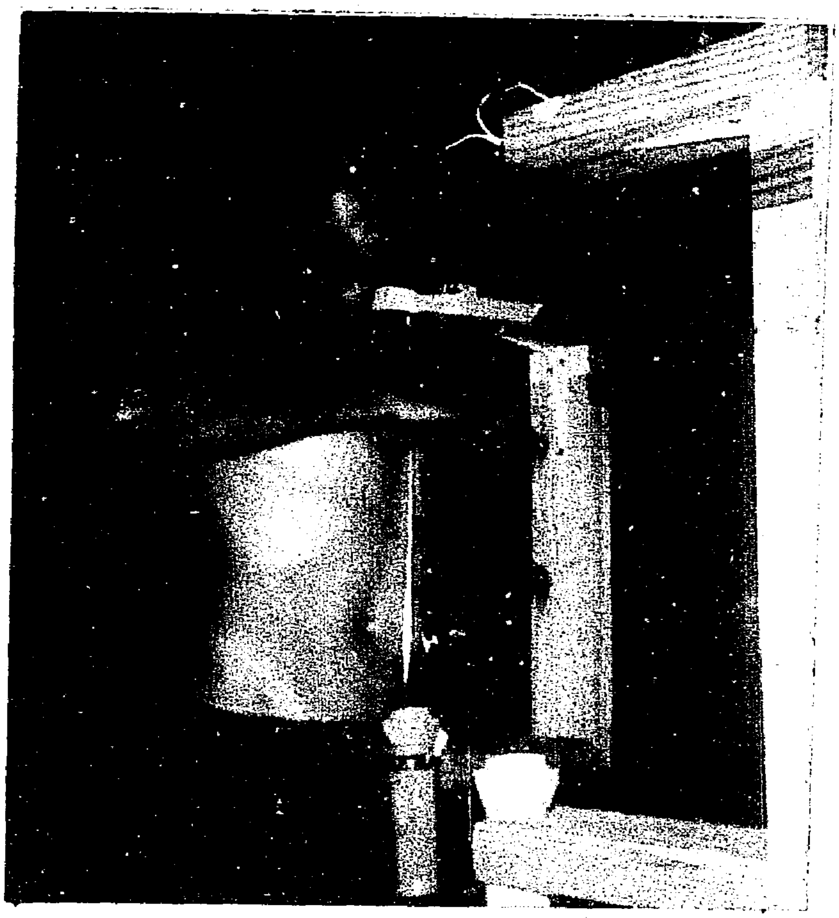

Figure 1. Testing apparatus and starting position of subjects for tests of arm reaction and movement times.

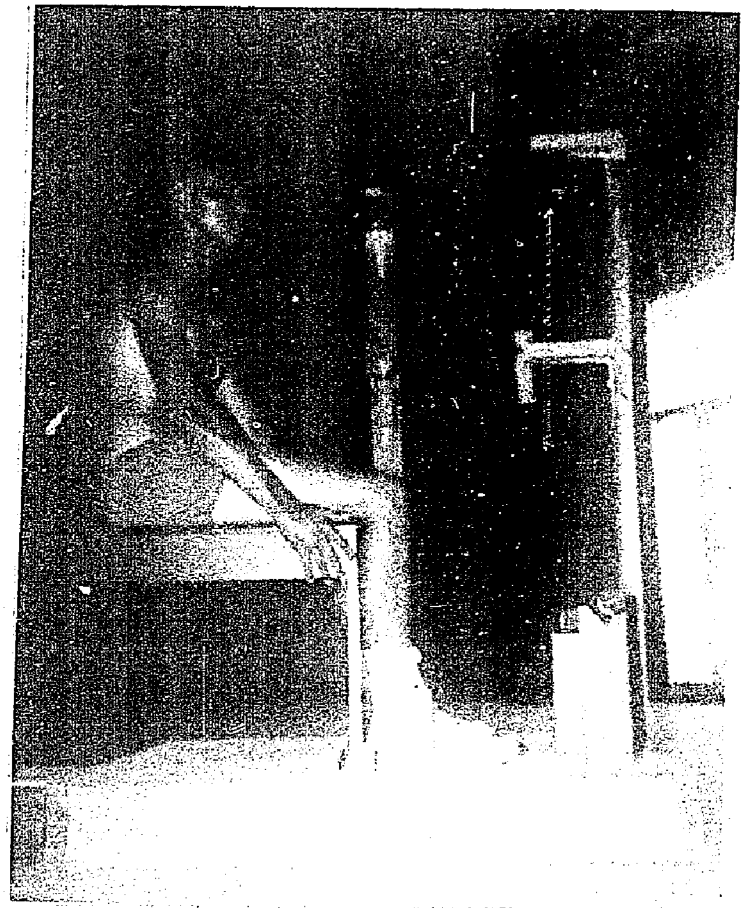

Figure 2. Testing apparatus and starting position of subjects for tests of leg reaction and movement times.

III. TESTING PROCEDURE

Arm Reaction Time Test. For this measurement the subject was requested to assume a standing position with the midline of his body aligned with the metal bar of the testing apparatus. With the body as close to the bar as possible, he was instructed to place his right hand in the light beam with the thumb against the bar at the height of his sternum. The right hand and forearm were straight and held parallel to the floor. Upon perception of the light stimulus, the subject moved the arm in a lateral abductive movement toward the second light beam.

The timing device was started by the tester giving the light stimulus, and was stopped when the subject's right hand moved out of the first light beam. See Figure 1, page 21, for starting position for arm reaction and movement tests.

Arm Movement Time Test. For this test, the subject assumed the same posture as for the test of arm reaction time. The metal bar, however, was moved back so that the right hand was behind the first light source. No light stimulus was given in the movement time test; the subject was instructed to execute the arm movement when he was ready.

The timer started when the subject's right hand entered the first light beam and stopped when his hand contacted the second light source. (See Figure 1 for starting position for arm reaction and movement time tests.)

Leg Reaction Time Test. The subject was instructed to assume a sitting position on the bench with the right leg placed perpendicular to the floor and at a 90^{o} angle with the thigh. His hands were placed to the sides of the bench and the left leg was placed on the floor to the left of the bench. The subject's right leg was placed in the light beam with the heel against the front edge of the bench. When the light stimulus was presented, the subject performed a forward extension of the leg, as in a kicking motion.

The timer started when the light stimulus was presented and was stopped when the subject's right leg was removed from the beam of the light.

Leg Movement Time Test. The same kicking movement studied in measuring leg reaction time was performed in the leg movement time test. In this phase of the testing, however, the bench was moved back so that the subject's right leg was two inches behind the light beam. No light stimulus was given in this test; the subject was asked to perform the movement when he was ready.

Timing for the movement phase of the testing started when the subject's right leg entered the first light beam and stopped when his leg entered the second light beam. (See Figure 2, page 22, for leg reaction and movement time test position.)

Scoring of the Tests. For each of the four events, the subject was given one practice trial and three test trials. The sum of the measurements taken on the three test trials became the score for that particular event.[2] Measurements were recorded in ten thousandths of a second.

IV. ISOMETRIC EXERCISE PROGRAM

Two functional isometric exercises were performed by Groups II and IV in this study. The subjects in these groups performed one leg and one arm exercise for ten seconds duration at maximum effort. The exercises were done three days a week for a period of six weeks. Nylon belts with adjustable lengths were used as resistance for the isometric exercises.

Isometric Arm Exercise. From the starting position described in the arm reaction test, the right arm was moved in a lateral abductive position eight inches from the chest. A nylon belt was then placed three inches above the wrist and wrapped around the chest of the subject. The subject exerted maximum effort against the belt. (See Figure 3 for isometric arm exercise position.)

Isometric Leg Exercise. From a sitting position with the right leg at a 90° angle to the thigh, the right leg was extended so that the foot was approximately eight inches from the starting position described in the leg reaction test. The nylon belt was placed three inches above the ankle and anchored behind the exercise bench. The subject then exerted a maximum isometric contraction leg extension

[2] Raw scores for the initial and final tests of reaction and movement times are shown in Appendix A.

Figure 3. Exercise position for functional isometric contraction of the lateral abductive arm movement.

against the belt for a period of ten seconds. (See Figure 4 for the isometric leg exercise position.)

V. STRENGTH TESTING PROCEDURE

It was not the puspose of this study to compare the different groups for gains in strength. However, it was felt that strength testing was necessary for those subjects performing isometric exercises in order to determine whether they were doing the exercises correctly. Therefore, only those subjects in Groups II and IV were tested for strength gains.

An improvised spring scale was attached to the nylon exercise belt and used to test both leg and arm strengths of the subjects. The scale was made by combining three twenty-five pound spring scales. For convenience, only one scale was read in determining the strength score[3] of the subject. Therefore, the strength scores throughout the study will be referred to as merely units of pull and not in pounds or any other standard measures. The scale used to test arm and leg strength is shown in Figure 5, page 29.)

<u>Arm Strength Test</u>. Arm strength of the subjects was measured in the same position that was used for the isometric exercise. A spring scale was attached to the exercise belt and the subject was instructed to exert maximum effort during the test. The amount of pull

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[3]Initial and final strength scores are shown in Appendix B.

Figure 4. Exercise position for functional isometric contractions of forward leg extension.

Figure 5. Improvised spring scale used to measure arm and leg strength.

registered against the scale was recorded as the subject's strength score.

Leg Strength Test. The leg strength test was administered with the leg in the same position used in the isometric leg exercise. The subject exerted maximum force in the leg extension movement. The highest reading on the scale was then recorded as his leg strength score.

VI. STATISTICAL DESIGN

A two by two factorial design was used for analyzing the results of the various treatments on reaction and movement times. The two factors of isometric exercise and softball were treated at two levels--activity and non-activity. The design was as follows:

	Isometric Exercise vs.	No Isometric Exercise
Softball vs.	Group IV (Isometric and Softball)	Group III (Softball
No Softball	Group II (Isometric	Group I (Control)

Figure 6. Statistical design for analysis of co-variance for tests of reaction and movement times.

VII. TREATMENT OF DATA

The Data Processing Center at Louisiana State University, Baton Rouge, Louisiana, was utilized in the statistical analysis of the data gathered in this study. The initial and final scores on the tests of arm reaction time, arm movement time, leg reaction time, and leg movement time were programmed on IBM cards which were then analyzed by the IBM 1620 Computer. A two-way analysis of co-variance was computed in order to determine the effects of the activities on the reaction and speed of movement times investigated in the study.

Analysis of Strength Data. Initial and final strength scores were analyzed by a comparison of means described by Garrett.[4] Means, standard deviations, standard errors of the means, differences in means, and *t* ratios were computed for the groups using isometric exercises to determine whether any significant gains in strength occurred during the six week isometric training program.

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[4]Henry E. Garrett, *Statistics in Psychology and Education.* (New York: Longmans, Green and Co.), 1959. pp. 212-17.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The data for each of the tests of arm reaction time, arm movement time, leg reaction time, and leg movement time obtained in this study were analyzed in three categories representing the three degrees of freedom available for differences among the four groups studied. In category "A" were those subjects (Groups II and IV) who took part in the isometric exercise program compared with those subjects (Groups I and III) who did not perform the exercises. In category "B" were those subjects who participated in the unit of softball activity (Groups III and IV) compared with those who did not play softball. The remaining degree of freedom is associated with any variation among the four groups not accounted for by "A" and "B" and represents a failure of the effects of these two to be additive. This effect is the interaction between "A" and "B".

In order to determine whether the groups differed in the final tests, as a result of the different training programs, analysis of co-variance was employed to allow for the correlation between initial and final scores. By this method, the final scores were automatically corrected for any differences that may have existed in the initial scores in the tests of arm reaction time, arm movement time, leg reaction time, and leg movement time. The results of the analysis for the four tests of reaction and movement times are presented in

Table I. "A" represents the effects of isometric exercises on the variables studied; "B" is the effects of softball activity on each variable; and "AxB" is associated with the interaction of the two categories on the measurements under study.

In Appendices G, H, I, and J, the initial and final means of arm and leg reaction times and speed of movement times are presented.

I. ANALYSIS OF ARM REACTION TIME DATA

From Table I, the comparison of isometric exercise groups with the non-isometric groups (category A) revealed an "F" ratio of 40.86 in favor of the isometric exercise subjects. For the degrees of freedom shown, an "F" ratio of 3.92 and 6.84 was needed for significance at the .05 and .01 levels of confidence, respectively.[1] The "F" ratio of 40.86 was therefore clearly significant at the .01 level of confidence and indicated that functional isometric exercises improved arm reaction time.

The "F" ratio of .74 for "B" was not found to be significant and indicated that softball activity had no significant effect on arm reaction time within the limits of this study.

An "F" ratio of 19.64 for the interaction AxB was also found to be significant at the .01 level of confidence. The mean changes in mean scores shown in Appendices G, H, I, and J revealed a significant difference between the isometric exercise group and the

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[1] <u>Ibid</u>., p. 454.

TABLE I

ANALYSIS OF CO-VARIANCE FOR TESTS OF REACTION AND MOVEMENT TIMES

Test	Source of Variation	df	Mean Squares	F ratio
Arm Reaction	Total	131		
	A	1	5,859,157	40.86**
	B	1	106,530	.74
	AxB	1	2,816,563	19.64**
	Error	128	143,369	--
Arm Movement	Total	131		
	A	1	451,010	10.75**
	B	1	106	.003
	AxB	1	9,666	.23
	Error	128	41,946	
Leg Reaction	Total	131		
	A	1	4,533,430	19.17**
	B	1	62,375	.26
	AxB	1	75,968	.32
	Error	128	236,388	
Leg Movement	Total	131		
	A	1	866,653	24.80**
	B	1	92,882	2.66
	AxB	1	21,190	.61
	Error	128	34,938	

**Indicates significance at the .01 level of confidence.

A Isometric groups compared with the non-isometric groups
B Softball groups compared with the non-softball groups
AxB The interaction of "A" and "B"
Complete analyses for all tests are shown in Appendices C-F, pp. 53-56.

group which participated in both softball and isometric training. This interaction indicated that the addition of softball to the isometric exercise program was responsible for slower arm reaction times. However, there is no apparent reason why this should have occurred. In light of the non-significant interaction found in the other three tests, it was believed that this was a chance occurrence and in reality softball activity had no effect on the variable studied.

II. ANALYSIS OF ARM MOVEMENT TIME DATA

It is shown in Table I that significant gains in arm movement time were made by those engaged in isometric exercise training. The "F" ratio of 10.85 in favor of the isometric exercise groups as compared to the non-isometric groups (category "A") was significant at the .01 level of confidence.

The "F" ratio for the softball groups versus the non-softball groups (category "B") and the "F" ratio, .23, for the interaction (AxB) of isometric exercise and softball were not found to be significant and indicated that neither softball activity nor the addition of softball to the isometric exercise program were responsible for significant changes in arm movement time.

III. ANALYSIS OF LEG REACTION TIME DATA

The only significant difference in leg reaction time revealed in Table I was attributed to the use of isometric exercise. The "F" of 19.17 in favor of the isometric exercise groups (category "A") was found to be significant at the .01 level of confidence.

"F" ratios of .26 for the softball groups compared with the non-softball groups (category "B") and .32 for the interaction (AxB) revealed that neither softball nor the addition of softball to the isometric exercise program caused any significant change in leg reaction time.

IV. ANALYSIS OF LEG MOVEMENT TIME DATA

Table I, page 34, shows that leg movement time was also improved significantly through the use of isometric exercises. The "F" ratio of 24.80 in favor of the isometric exercise subjects (category "A") was clearly significant at the .01 level of confidence.

The "F" ratio of 2.66 for category "B" was not significant and indicated that softball activity had no apparent effect on the leg movement times of the subjects studied.

No significant changes in leg movement times were caused by the addition of softball to the isometric exercise program as evidenced by the non-significant "F" ratio of .61 found for the interaction of isometric exercise and softball.

V. ANALYSIS OF STRENGTH TEST SCORES

Functional isometric exercises of the arm and leg were found to be effective means of producing strength gains as measured in this study. The differences in initial and final arm and leg strength measures made by the groups using isometric exercises during the course of this study are shown in Table II.

Arm Strength. The initial mean scores in arm strength for the sixty-eight subjects who participated in the isometric exercise program was increased from 9.53 to a final mean score of 13.5 units of pull. A comparison of these means revealed a *t* ratio of 9.57 which was significant at the .01 level of confidence.

Leg Strength. The mean leg strength scores of the isometric exercise groups was increased from 14.15 at the beginning of the study to 19.22 units of pull at the end of the six week training period. The observed difference of 5.07 was tested for significance and the resulting *t* ratio of 10.97 was found to be clearly significant at the .01 level of confidence.

TABLE II

DIFFERENCES BETWEEN MEANS OF INITIAL AND FINAL ARM AND LEG STRENGTH SCORES FOR THE ISOMETRIC EXERCISE GROUPS

Test	N	Mean	S.D.	$S.E._{Mean}$	Observed Diff.	$S.E._{Diff.}$	t
Initial Arm Strength	68	9.53	1.77	.22			
Final Arm Strength	68	13.15	2.10	.25	5.07	.53	9.57
Initial Leg Strength	68	14.15	2.84	.34			
Final Leg Strength	68	19.22	3.03	.37	3.62	.33	10.97

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

It was the purpose of this study to determine the effects of functional isometric exercises on reaction and movement times of the arm and leg.

One hundred and thirty-six male students at Louisiana Polytechnic Institute, Ruston, Louisiana served as subjects for this study. The subjects were divided into four groups: (1) Group I, the control group, was tested and re-tested with no intervening physical activity; (2) Group II performed isometric exercises of the lateral arm and leg extension movements for a period of ten seconds each three days a week for six weeks; (3) Group III participated in a six-week unit of softball activity as part of the regular required program of physical education; (4) the subjects in Group IV participated in the softball unit and, in addition, performed isometric exercises of the arm and leg.

All subjects were tested for arm reaction time, arm movement time, leg reaction time, and leg movement time at the beginning of the experiment. At the end of the six-week training period, all subjects were retested in an effort to determine whether or not significant changes in reaction and movement times occurred during the study.

In addition to the tests of reaction and movement time, the subjects who participated in the isometric exercise program were tested at the beginning and end of the study to find whether gains in strength resulted from the isometric program. These subjects were also tested periodically throughout the six-week period as a means of motivating them to perform at maximum effort.

An analysis of co-variance was utilized in treating the data to determine the effects of the different programs on the reaction and movement times tested. This analysis was made on the IBM 1620 Computer at the Data Processing Center at Louisiana State University, Baton Rouge, Louisiana. The $\underline{t}$ test of significance was utilized in comparing the differences between the original and final mean scores of arm and leg strength measured for those subjects who participated in the isometric exercise program.

The following findings were obtained in this study:

1. Functional isometric exercises were effective in the improvement of arm reaction time, arm movement time, leg reaction time, and leg movement time as measured in this experiment.
2. Participation in softball activity failed to cause any significant changes in the mean scores of arm reaction time, leg reaction time, leg movement time, and arm movement time.
3. The addition of physical activity, softball, to functional isometric exercises did not contribute toward improvements

in reaction and movement time.

4. The subjects in the control group showed no significant changes in arm reaction time, arm movement time, leg reaction time, or leg movement time.

5. Those subjects performing functional isometric exercises showed significant gains in strength of the arm and leg which indicated that the subjects were doing the exercises correctly.

II. CONCLUSIONS

Within the limitations of this study, the data justified the following conclusions:

1. Functional isometric contractions will result in improved reaction times and speed of movement times of the arm and leg as measured in this study.

2. The addition of softball activity to the functional isometric exercise program does not cause significant gains in reaction and movement time as opposed to the use of isometric exercise alone.

3. Softball activity alone does not result in any significant changes in reaction and movement time as measured in this study.

III. RECOMMENDATIONS

1. Other studies should be made to determine the effects of a general isometric training program on reaction time and

movement time as opposed to the functional exercises used in this study.

2. A further study to determine the manner in which isometric exercises affect more complex movements and total body reaction and movement times is recommended.
3. Further studies to determine the influences of isometric training on other physical factors such as balance, rhythm, and flexibility would be of value.

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APPENDIX A

INITIAL AND FINAL RAW SCORES* FOR REACTION AND MOVEMENT TESTS FOR GROUP I

Subjects	Arm Reaction I	Arm Reaction II	Arm Movement I	Arm Movement II	Leg Reaction I	Leg Reaction II	Leg Movement I	Leg Movement II
1	7394	7123	2955	2855	7673	7579	2104	1966
2	8469	8342	3217	2689	9265	9260	2350	2298
3	7606	7542	1749	2168	8555	8312	2340	2273
4	7878	7154	2065	2000	8523	8385	2130	1840
5	8866	8011	2082	2053	8560	7902	2298	2013
6	8827	7397	2114	2110	8974	9027	2275	2124
7	7787	7883	1998	2045	8536	7443	1643	1562
8	9191	7341	1953	2014	8024	7036	2143	1997
9	7681	8173	2406	2417	9405	9257	2162	2133
10	7921	7971	2260	2142	8791	7924	2059	1911
11	7999	7570	2401	2659	9569	8931	1980	1969
12	7964	6256	2015	2017	8165	6825	2031	1645
13	8465	8362	2843	2530	9436	8111	2271	1842
14	7207	7206	2272	2136	8626	7231	2565	2004
15	8942	6966	2562	2387	7791	7667	2700	2367
16	7529	7509	2426	2354	8628	8443	2389	2006
17	8319	7947	2453	2178	8083	8075	1673	1446
18	8605	7833	2519	2074	9000	8891	2160	2016
19	8446	7222	3453	3147	8647	8713	1769	1748
20	7718	7461	2161	2025	9067	8398	1867	1772
21	9284	7992	1929	1959	9334	8375	1527	1599
22	8307	8180	1915	1945	9042	9011	2128	2052
23	8248	8185	1996	1923	8465	8183	2097	2001
24	7601	7477	1848	1910	7332	7275	1998	1929
25	5967	5320	1810	1896	7156	6536	1828	1953
26	6716	6557	2185	2243	9105	8891	2110	2074
27	8133	7669	3104	2497	7952	7744	2078	1922
28	7864	7837	1890	1786	7524	7308	1889	1593
29	7808	7645	1764	1832	8502	8101	1798	1526
30	8175	7761	2754	2657	8914	8319	3353	2055
31	7796	7658	2459	2444	9395	7081	2244	2184
32	7886	7574	3513	2526	8382	8176	2094	1679
33	8753	7147	2284	2109	8883	8164	2146	2233
34	8732	8326	2633	2478	9291	8872	2819	2266

*Scores are given in 1/10,000ths of a second.

INITIAL AND FINAL RAW SCORES* FOR REACTION AND MOVEMENT

TIMES FOR GROUP II

Subjects	Arm Reaction I	Arm Reaction II	Arm Movement I	Arm Movement II	Leg Reaction I	Leg Reaction II	Leg Movement I	Leg Movement II
1	7357	7334	1878	2039	7740	7743	2387	2270
2	8477	7871	2673	2629	7883	7787	2505	1879
3	8706	8550	2529	2025	8729	8463	2215	1654
4	9002	8583	3117	2542	8072	7937	2023	1924
5	8990	8778	2170	2325	9466	9091	2325	2329
6	8646	7918	2268	2164	8989	8569	2469	2350
7	7395	7083	3476	3326	8390	8323	2500	2455
8	8609	7743	2054	1884	8884	5769	2055	1891
9	7014	6979	1988	1980	7507	7528	2064	1839
10	7846	7594	1942	2024	8109	7699	2243	2076
11	7651	7429	2357	2241	7701	7218	2378	2012
12	7657	6949	2425	2328	8464	8192	2704	2528
13	7298	7668	3547	2917	9365	8706	2435	2182
14	8419	7739	1866	1910	8881	8388	2204	2380
15	6555	6203	2078	2123	7816	7414	2494	2280
16	8275	8014	2227	2168	9614	8995	2747	2260
17	8650	7493	2219	2264	9083	8463	2273	2044
18	7936	7814	2264	2632	8189	7936	2644	2626
19	9464	9161	2191	2385	9280	8916	2045	2129
20	7697	7250	2301	2185	7807	7613	1450	1563
21	7930	7944	2133	2141	8055	7457	2412	2570
22	7462	7567	2898	2242	9381	8903	2011	2032
23	8391	7704	2222	2287	9257	8781	2215	2345
24	7617	7422	1696	1928	8678	8550	1980	1689
25	8207	8042	2003	2106	8311	8475	2791	2330
26	7497	7282	2969	2228	6543	6545	2313	2119
27	8215	7975	1978	1995	8319	8048	1819	1658
28	7116	7217	1710	1965	7783	7803	1892	1580
29	6837	6878	2335	2266	8837	8098	2156	1644
30	8356	8001	2746	2231	9023	7912	2075	2323
31	7956	7738	2447	2201	7967	7502	1973	1860
32	7603	7495	2557	2495	7454	6815	2966	2403
33	7516	7505	2623	2389	8585	8377	1657	1717
34	7896	7653	2353	2438	8069	8083	1730	1692

*Scores are given in 1/10,000ths of a second.

INITIAL AND FINAL RAW SCORES* FOR REACTION AND MOVEMENT

TIMES FOR GROUP III

Subjects	Arm Reaction I	Arm Reaction II	Arm Movement I	Arm Movement II	Leg Reaction I	Leg Reaction II	Leg Movement I	Leg Movement II
1	8129	8148	2971	2153	8447	8541	2526	2472
2	7272	7313	1768	1908	8529	7186	1587	1981
3	8046	8279	2218	2514	8259	8236	2200	2233
4	7556	7643	2755	2537	8218	8089	2363	2097
5	8852	7876	2430	2614	9042	8939	1865	2277
6	8422	8660	2260	2338	8969	9062	1966	1720
7	8128	8146	2051	2206	8560	8624	2273	2248
8	7830	7942	2177	2244	7925	7861	2142	2118
9	7673	7910	2288	2227	7440	7118	2088	2169
10	7782	8025	2041	2137	8530	7965	2905	2744
11	7851	7460	2720	2602	8367	7810	2177	2406
12	8044	8112	2029	2088	7773	7927	2375	2614
13	8704	8155	2682	2797	9170	9378	2110	2062
14	8284	8301	2222	2291	8434	8308	1700	1693
15	8707	8440	2824	2712	9128	8535	3165	2640
16	8379	8157	2330	2580	8849	8779	2365	2509
17	7883	7856	2093	2199	8912	8678	1980	2117
18	8131	8950	2609	2690	7853	8433	1670	1569
19	7843	7959	2309	2267	7728	8035	1956	1898
20	8343	7065	2663	2650	8144	8280	2878	2800
21	7708	8771	2098	2204	8600	8445	2998	2347
22	7826	7788	1923	2044	8074	8329	2665	2526
23	8435	8130	2234	2357	8112	8337	2093	2266
24	7916	7812	2465	2397	8017	7728	2442	2303
25	8549	8713	2217	2191	9003	8915	2676	2430
26	7595	7827	2122	2145	7687	7842	1823	1863
27	8593	8860	2466	2279	8402	8824	2582	2501
28	7413	7567	2317	2183	8130	8199	2120	1935
29	8021	7701	2687	2097	8801	7855	2086	2234
30	6280	6455	2275	2348	7318	7551	2177	2206
31	8029	7436	2434	2429	7944	7883	2485	2241
32	7869	7835	1979	2322	7696	8955	2526	2425
33	8287	8559	2076	2549	8734	8558	2092	2067
34	8241	7765	2145	2185	8892	8317	2263	2231

*Scores are given in 1/10,000ths of a second.

INITIAL AND FINAL RAW SCORES* FOR REACTION AND MOVEMENT

TIMES FOR GROUP IV

Subjects	Arm Reaction I	Arm Reaction II	Arm Movement I	Arm Movement II	Leg Reaction I	Leg Reaction II	Leg Movement I	Leg Movement II
1	7602	7444	2449	2581	7727	8054	2174	2388
2	8110	8143	2770	2331	8949	7947	1819	1747
3	7506	7645	2677	2568	6163	7680	1425	1801
4	6724	6979	2247	2688	7098	8038	1946	1605
5	8449	8719	2291	2283	8959	9010	2208	1938
6	8095	8000	1913	2108	8332	8655	2117	2290
7	8170	7370	2566	2522	7094	7003	2312	1829
8	9074	9078	1954	2480	9730	9260	2393	2490
9	8194	8314	1784	2008	7649	8092	1943	2037
10	6718	7339	2528	2468	7574	8138	2103	2033
11	7389	7875	2171	2137	9038	8763	2388	2401
12	8383	8881	1658	2042	8755	9092	2026	2137
13	7801	8376	2476	2033	8129	8846	2346	2422
14	6745	7388	2489	2051	7621	7825	2026	1987
15	6889	7507	2062	2291	7934	7453	1832	2039
16	7268	7192	2166	2248	8181	7778	1825	1997
17	7618	7315	2711	2761	8972	8577	2510	2537
18	8194	7812	2112	2170	8265	8694	2419	2216
19	7767	7906	2475	2308	5902	7439	2046	2083
20	8693	8613	1728	1733	8215	8643	1463	1650
21	6547	7235	2591	2248	7968	7172	1913	1750
22	6983	7589	2440	2455	8149	8370	1484	1641
23	7224	7334	2576	2186	7015	7756	2158	1922
24	8059	7902	2195	2226	8883	8948	1916	2045
25	8911	9234	2020	2183	9846	9498	2546	2603
26	7742	7656	2825	2390	8288	7794	2049	2179
27	9180	8911	2669	2559	8865	8569	2128	1875
28	8222	8246	3832	3500	7491	8381	1644	1688
29	8812	8942	1965	2521	8392	8225	2249	2398
30	7031	7571	1864	2142	7915	8143	1806	1904
31	8166	7542	2388	2317	7689	7997	2307	2269
32	9066	8746	2220	2022	8331	8415	2092	2105
33	7252	7427	2293	2533	8198	7497	2012	2134
34	8064	8280	4431	4574	8213	7576	1835	1930

*Scores are given in 1/10,000ths of a second.

APPENDIX B

INITIAL AND FINAL RAW SCORES* OF ARM AND LEG STRENGTH

FOR GROUP II

Subject	Arm Strength I	Arm Strength II	Leg Strength I	Leg Strength II
1	8	13	12	17
2	8	14	13	19
3	7	11	12	17
4	7	14	10	20
5	7	19	11	23
6	11	12	13	19
7	10	11	12	15
8	8	10	12	18
9	11	17	12	18
10	8	10	10	20
11	8	13	10	14
12	10	10	10	12
13	10	14	14	18
14	10	11	12	16
15	10	14	14	15
16	9	11	11	13
17	12	18	14	23
18	15	19	19	21
19	8	13	10	18
20	9	16	12	18
21	10	16	14	19
22	8	11	12	15
23	10	10	14	18
24	9	15	12	20
25	10	22	13	25
26	10	13	12	24
27	6	15	13	18
28	8	13	11	17
29	10	13	14	21
30	10	15	13	20
31	9	14	11	16
32	9	14	10	16
33	10	18	13	22
34	8	15	10	20

*Scores represent approximately 1/3 pound.

INITIAL AND FINAL RAW SCORES* OF ARM AND LEG STRENGTH FOR GROUP IV

Subject	Arm Strength I	Arm Strength II	Leg Strength I	Leg Strength II
1	8	12	10	17
2	9	15	12	18
3	12	16	16	24
4	11	15	13	22
5	12	14	12	20
6	12	14	15	18
7	7	10	13	17
8	9	15	13	18
9	9	15	13	25
10	10	15	13	17
11	12	18	18	25
12	9	12	12	17
13	7	15	13	23
14	8	16	12	22
15	12	18	16	23
16	8	12	13	15
17	13	16	15	19
18	12	17	14	22
19	8	9	12	15
20	7	10	8	12
21	9	13	14	19
22	9	14	14	21
23	13	16	15	23
24	10	18	14	25
25	6	10	10	23
26	11	20	14	22
27	9	14	13	19
28	10	14	12	18
29	11	19	19	22
30	9	11	13	21
31	12	18	17	25
32	9	11	12	18
33	12	14	14	16
34	11	12	14	21

*Scores represent approximately 1/3 pound.

APPENDIX C

CO-VARIANCE ANALYSIS OF ARM REACTION TIME DATA

Source	df	Σx^2	Σxy	Σy^2	Corrected Σy^2	M.S.	"F"
Total	131	57,287,784	36,714,533	50,590,934	--	--	--
A	1	166,459	- 873,024	4,578,692	5,859,157	5,859,157	40.86
B	1	24,677	68,485	190,051	106,530	106,530	.74
AxB	1	665,560	-1,810,132	60,734	2,816,563	2,816,563	19.64
Error	128	54,431,088	39,329,204	45,761,457	18,351,277	143,369	--

A = Effect of Isometric Exercise
B = Effect of Softball Activity
AxB = Interaction of A and B

APPENDIX D

CO-VARIANCE ANALYSIS OF ARM MOVEMENT TIME DATA

Source	df	Σx^2	Σxy	Σy^2	Corrected Σy^2	M.S.	"F"
Total	131	26,571,725	16,718,811	16,307,256	--	--	--
A	1	230	10,337	463,906	451,010	451,010	10.75
B	1	42,246	24,410	14,104	106	106	.003
AxB	1	62,631	63,982	65,340	9,666	9,666	.23
Error	128	26,466,598	16,620,082	15,763,906	5,327,086	41,946	--

A = Effect of Isometric Exercise
B = Effect of Softball Activity
AxB = Interaction of A and B

APPENDIX E

CO-VARIANCE ANALYSIS OF LEG REACTION TIME DATA

Source	df	Σx^2	Σxy	Σy^2	Corrected Σy^2	M.S.	"F"
Total	131	66,154,917	38,756,468	57,355,296	--	--	--
A	1	2,827,300	-1,831,856	1,186,889	4,533,430	4,533,430	19.17
B	1	23,638	-23,112	22,595	62,375	62,375	.26
AxB	1	1,550,437	655,687	277,294	75,968	75,968	.32
Error	128	61,753,542	39,955,749	55,873,478	30,021,327	236,388	--

A = Effect of Isometric Exercise
B = Effect of Softball Activity
AxB = Interaction of A and B

APPENDIX F

CO-VARIANCE ANALYSIS OF LEG MOVEMENT TIME DATA

Source	df	Σx^2	Σxy	Σy^2	Corrected Σy^2	M.S.	"F"
Total	131	16,341,727	10,228,153	11,827,446	--	--	--
A	1	42,071	-164,995	647,081	866,653	866,653	24.80
B	1	888,735	849,367	811,743	92,882	92,882	2.66
AxB	1	164,089	42,966	11,250	21,190	21,190	.61
Error	128	19,246,832	9,500,815	10,357,372	4,437,094	34,938	--

A = Effect of Isometric Exercise
B = Effect of Softball Activity
AxB = Interaction of A and B

APPENDIX G

MEAN CHANGES* IN ARM REACTION TIMES FOR ALL GROUPS STUDIED

Group	Initial Mean	Corrected Final Mean
I. Control	7851	8042
II. Isometric Exercise	8061	7481
III. Softball	8018	7954
IV. Isometric with Softball	7948	7680
Combined Groups		
Isometric Groups (II, IV)	8005	7581
Non-Isometric Groups (I, III)	7935	7948
Softball Groups (III, IV)	7983	7817
Non-Softball Groups (I, II)	7956	7762

*Means given in ten thousandths of a second.

APPENDIX H

MEAN CHANGES* IN ARM MOVEMENT TIMES FOR ALL GROUPS STUDIED

Group	Initial Mean	Corrected Final Mean
I. Control	2398	2377
II. Isometric Exercise	2353	2244
III. Softball	2320	2362
IV. Isometric with Softball	2360	2264
Combined Groups		
Isometric Groups (II, IV)	2356	2254
Non-Isometric Groups (I, III)	2359	2369
Softball Groups (III, IV)	2340	2312
Non-Softball Groups (I, II)	2375	2311

*Means given in ten thousandths of a second.

APPENDIX I

MEAN CHANGES* IN LEG REACTION TIMES FOR ALL GROUPS STUDIED

Group	Initial Mean	Corrected Final Mean
I. Control	8104	8380
II. Isometric Exercise	8606	8064
III. Softball	8344	8296
IV. Isometric with Softball	8419	7970
Combined Groups		
Isometric Groups (II, IV)	8512	7967
Non-Isometric Groups (I, III)	8224	8342
Softball Groups (III, IV)	8381	8133
Non-Softball Groups (I, II)	8355	8176

*Means given in ten thousandths of a second.

APPENDIX J

MEAN CHANGES* IN LEG MOVEMENT TIMES FOR ALL GROUPS STUDIED

Group	Initial Mean	Corrected Final Mean
I. Control	2043	2144
II. Isometric Exercise	2148	1958
III. Softball	2274	2173
IV. Isometric with Softball	2240	2037
Combined Groups		
Isometric Groups (II, IV)	2194	1998
Non-Isometric Groups (I, III)	2159	2158
Softball Groups (III, IV)	2257	2144
Non-Softball Groups (I, II)	2095	2106

*Means given in ten thousandths of a second.

VITA

The author was born in Homer, Louisiana on March 23, 1930. He obtained his elementary and high school education at Homer High School from which he graduated in 1948.

He attended Louisiana Polytechnic Institute in Ruston, Louisiana and received his Bachelor of Science degree in 1948, with a major in Health and Physical Education. The Master of Science degree was obtained from Northwestern State College in Natchitoches, Louisiana in 1958, with a major in Health and Physical Education.

Work on the doctoral level was begun in 1961 at Louisiana State University and the Doctor of Education degree, with a major in Physical Education, was awarded in August, 1963.

Upon completion of two years of active duty with the U. S. Navy, he was employed by the Claiborne Parish School Board and served as teacher and coach at Homer, Louisiana and Haynesville, Louisiana for a period of seven years. He is presently employed at Louisiana State University at Alexandria, Louisiana, teaching Physical Education.

EXAMINATION AND THESIS REPORT

Candidate: Charles E. Michael

Major Field: Physical Education

Title of Thesis: The Effects of Isometric Contraction Exercise on Reaction and Speed of Movement Times

Approved:

Jack K. Nelson
Major Professor and Chairman

Max Goodrich
Dean of the Graduate School

EXAMINING COMMITTEE:

Dennis P Noah

J.W. Kistler

Elizabeth Moore

Lynden B Sherrill

F A Drury

Date of Examination: